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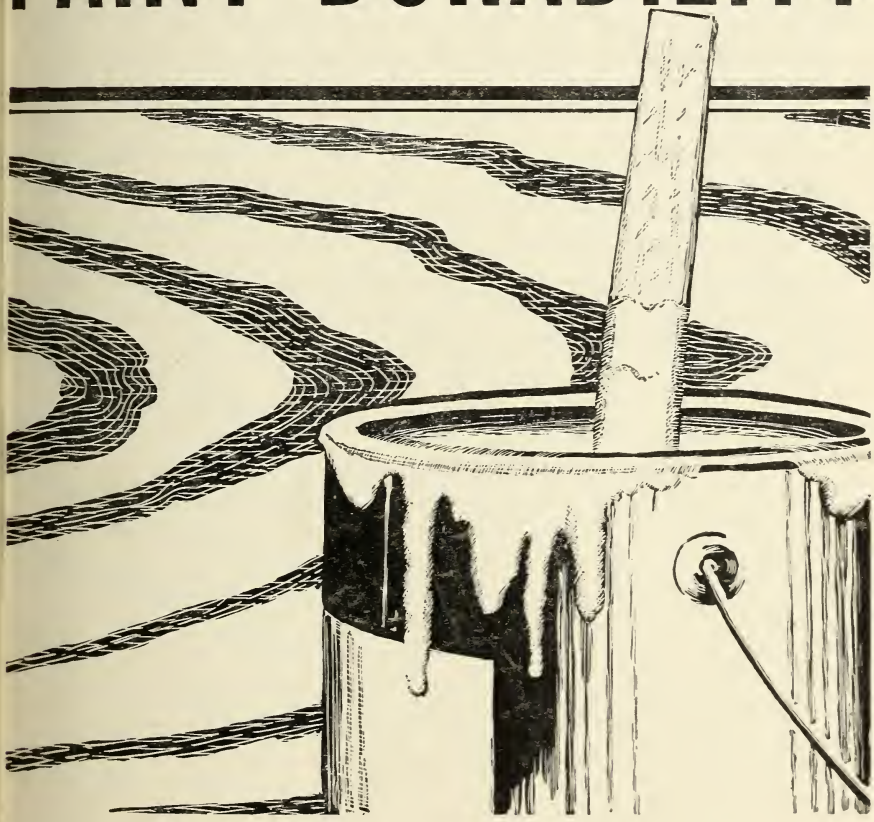
WOOD PROPERTIES AND PAINT DURABILITY



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CONTENTS

	Page
Wood properties that affect painting characteristics	1
Density and texture	1
Resins and oils	5
Moisture content	5
Knots and other defects	5
Selecting the best wood for painting	6
Selection by species	6
Selection by grade	8
Selection by kind of grain	8
Selection by density and texture	8
Suggestions for painting the heavier softwoods	8

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WOOD PROPERTIES AND PAINT DURABILITY[1]

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The longer a coat of paint lasts the lower the over-all painting costs will be. Information about how wood takes and holds paint is therefore of interest to all who use paint on new wood.

SOME kinds of wood hold coatings of outside house or barn paint longer than others. Even when all boards are of the same kind of wood, some stay coated longer than the rest. Moreover, when coatings wear out, the original grain pattern of the board is revealed by the sloughing paint, as shown in figure 1. The reasons behind this behavior largely explain the painting characteristics of wood. When the best woods cannot be selected for painting, careful choice of paints and painting methods the first time the wood is painted will partly offset the shortcomings of the wood. This publication explains how paint is affected by wood, and offers some suggestions for painting the more difficult woods.

Other factors besides the nature of the wood affect the durability of paint coatings, such as composition of the paint, skill with which the painting is done, number of times the surface has been painted, degree of shelter from the sun and rain (fig. 2), and climatic and local weather conditions. Under highly unfavorable conditions of service, the coating may wear out before there is time for the nature of the wood to show its effect. This publication, however, is concerned mainly with how wood affects the behavior of coatings of *good* paint, well applied and maintained, under ordinary conditions of service.

WOOD PROPERTIES THAT AFFECT PAINTING CHARACTERISTICS

The properties of wood that affect paintings are density and texture; content of resins, oils, and moisture; and defects, such as knots.

DENSITY AND TEXTURE

Among softwoods (conifers) the painting characteristics of a board depend primarily upon the amount and distribution of summerwood. Each year of its life a tree adds an annual ring composed of summerwood and

[1] Supersedes Leaflet No. 62, Why Some Wood Surfaces Hold Paint Longer Than Others.

[2] Maintained at Madison 5, Wis., in cooperation with the University of Wisconsin.

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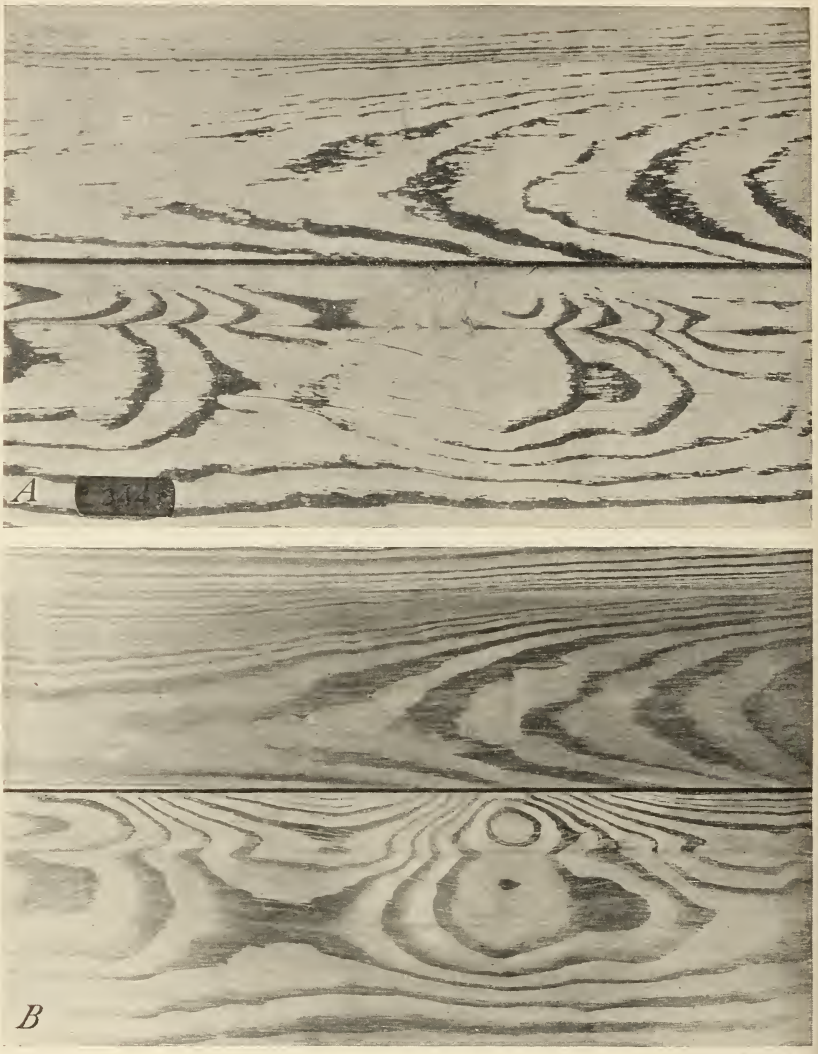

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Figure 1.—Paint fails soonest over the bands of summerwood in softwoods. *A,* These two boards were painted with white paint and exposed to the weather for 5 years. *B,* The same boards after remaining paint was taken off with paint remover, showing the dark bands of summerwood, indicated by the paint-bare areas in *A.*

springwood. Summerwood is the dense, horny, dark-colored portion of the annual growth ring, formed in the tree late in the growing season. It has wood cells with thick walls and small cavities. Springwood is the softer and lighter (in weight and color) portion of the growth rings, formed in the early part of the growing season, and has wood cells with thin walls and large cavities. Paint oils penetrate farther into summerwood than into

springwood, but the oil that penetrates is separated from the coating and does not help to hold the coating in place. New paint sticks firmly to both springwood and summerwood, but when the coating becomes old and brittle, it comes loose from the smooth summerwood, though it usually is held securely on the springwood. If the bands of summerwood are narrow enough the coating may bridge over the summerwood and remain in place, but if the bands are wide the coating breaks loose from them. Therefore, boards with narrow bands of summerwood are best for painting.

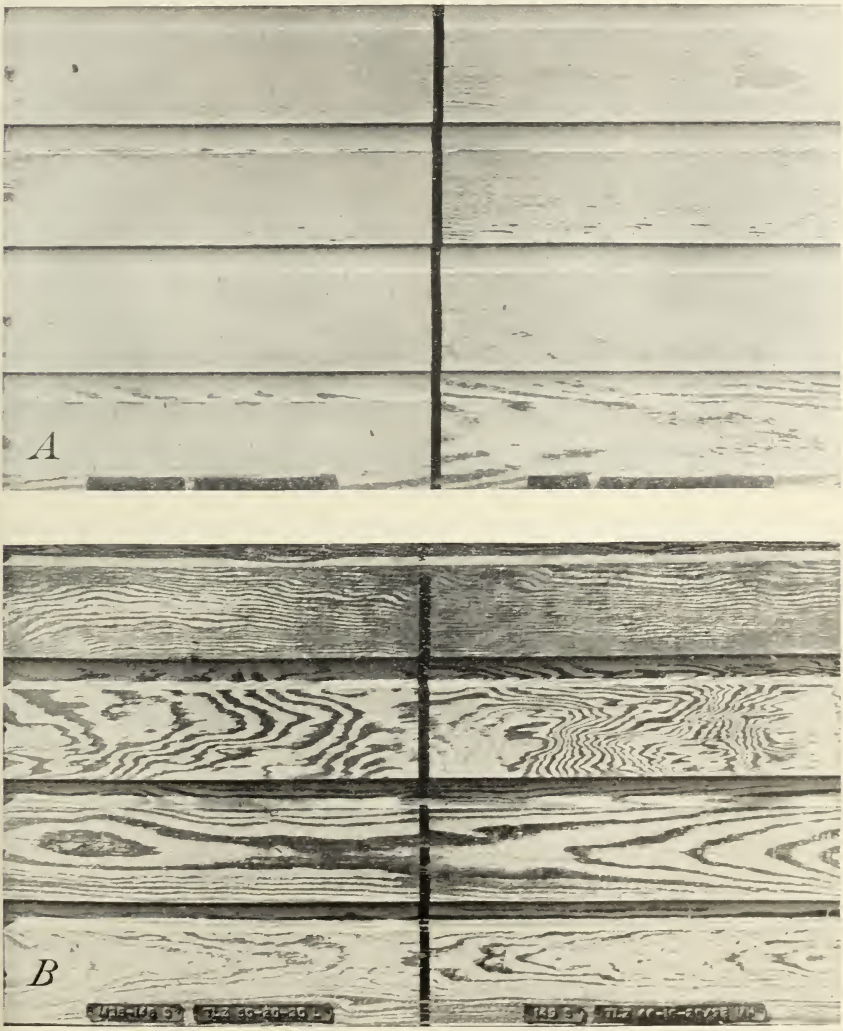

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Figure 2.—Paints last longer in the shade than in strong sunshine. Two house paints (one at the left, another at the right) applied on Douglas-fir and southern yellow pine, after exposure to the weather for 8 years; *A*, facing north, and *B*, facing south.

The width of the summerwood bands in softwood usually varies with the density (weight per unit of volume) of the wood and the rate of tree growth, being narrower when the density is low or the tree growth is slow. The density of softwood lumber is low when the proportion of summerwood is small. If a tree grew slowly, however, the bands of summerwood may be narrow even if the density is high because there are then many growth rings per inch of radius of the log (fig. 3). The manner of cutting the boards

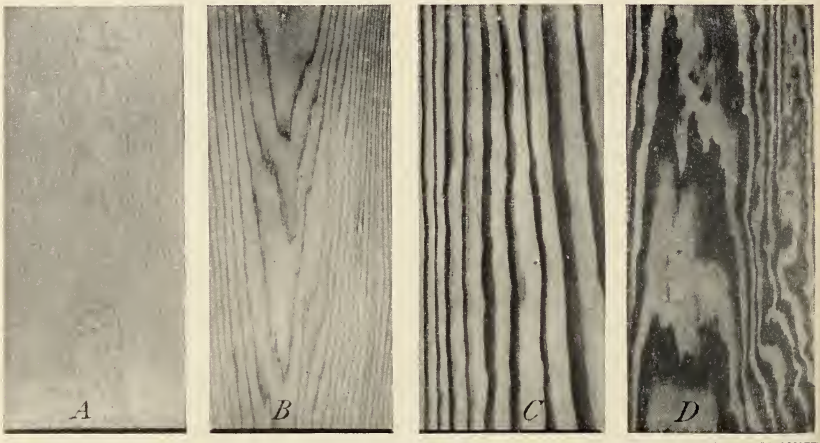

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Figure 3.—Paint-holding characteristics depend on wood texture and density. Boards *A* and *B* held paint well; boards *C* and *D*, poorly, when they were painted with house paint and exposed to the weather. Board *A* had 36 annual rings per inch of radius of the log and at 6-percent moisture content weighed 25 pounds per cubic foot; *B* had 27 annual rings and weighed 30 pounds; *C* had 6 rings and weighed 30 pounds; *D* had 15 rings and weighed 46 pounds.

from a log also affects the width of the summerwood bands exposed on the painting surface. Edge-grain boards (called quarter-sawn in hardwoods) have narrower bands of exposed summerwood than flat-grain boards. They are cut from the logs at right angles to the annual growth rings, and the edges of the growth rings appear on the painting surface of the boards. In flat-grain boards, which are cut at a different angle, the faces of the growth rings appear (fig. 1). In flat-grain boards the side that was nearer the bark often holds paint longer than the opposite side.

Hardwoods (broadleaved trees) differ in structure from softwoods. Hardwoods have fibers and pores. The size and arrangement of the pores, which are much larger than the fibers, govern the painting characteristics of the wood. Hardwoods such as oak, with pores larger than those in birch, are poorly adapted to painting with ordinary house paints because pinholes are left in the coating over the large pores. The pinholes not only are unsightly, but lead to early failure of the coating. The best hardwoods for painting are those of medium to low density, such as yellow-poplar, with pores no larger than those in birch.

RESINS AND OILS

Resins and oils in well-seasoned wood have less effect on painting than is generally supposed. The resin in pine lumber seems to shorten slightly the life of paints containing zinc oxide, but this unfavorable effect can be prevented by using modern priming paints free from zinc oxide. The essential oils in cypress and some of the cedars may delay the drying of some paints, but they prolong the life of the coatings.

In green lumber, however, the effects of resins and oils may be serious. Resin may exude when the painted wood is warmed by the sun or otherwise, and either push through or loosen the coating. Oils in unseasoned wood may completely prevent drying of some paints.

Occasionally on dry wood, but more often on wood that has been only partly dried or has become moist after seasoning, there is a discoloration of white or light-colored paint over the heartwood of ponderosa or white pines. The discoloration comes from brown substances in the resin of the heartwood, which are evidently more active when the wood is damp than when it is dry.

MOISTURE CONTENT

Paints last longest on wood that has been well seasoned but which has regained some moisture so its moisture content is 12 to 15 percent. Paints applied to very dry wood are slightly less durable. As a rule, however, it is best to paint wood when it has about the average moisture content that is expected to prevail during service.

Wet wood, the moisture content of which is over 25 percent, is in an uncertain condition for painting because there is grave danger of failure of the coating by blistering (fig. 4) and peeling. Blistering and peeling result from pressure against the back of a coating caused by expansion of air and water trapped in wet wood. Moreover, woods like redwood and redcedar, which contain colored substances soluble in water, may discolor paint applied while the wood is wet. Even if wood is dry when painted but later absorbs enough moisture to become thoroughly wet, there is danger of blistering, peeling, or discoloration.

KNOTS AND OTHER DEFECTS

Knots in wood produce serious blemishes in paint coatings. In pine lumber the paint over knots is often discolored by yellow or brown substances from the wood. End-grain wood in the knots of any wood often absorbs enough oil from paint to destroy the gloss of the paint. Both discoloration and oil absorption can be prevented by applying shellac or other spirit varnish over the knots before painting, but the paint is likely to crack badly and may flake from the knots fairly soon. Large knots are likely to crack even after they are painted, and the cracks may be too large to fill with new paint.

Pitch streaks or pitch pockets in wood mar paint coatings by causing the paint or crack or bake off, or by exuding resin.

Blue stain in sapwood can be concealed by paint as long as the wood can be kept dry. If at any time the wood becomes damp, however, the fungi causing the stain may become active and push through, discoloring the paint.

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Figure 4.—Blistering of paint coatings on wood siding caused by condensation of water behind the siding during cold weather. The badly blistered coating at the left consisted of three coats of a good-quality house paint. The slightly blistered coating at the right consisted of two coats of the same house paint applied over a priming coat of aluminum house paint. Paint failures of this kind can be entirely prevented only by permitting no water to get behind painted woodwork.

SELECTING THE BEST WOOD FOR PAINTING

Wherever wood is to be kept well-painted for a long time the cost of paint maintenance can be reduced by selecting kinds of wood that hold paint coatings most satisfactorily (fig. 5).

SELECTION BY SPECIES

Since paint-holding qualities are affected by the kind of wood, and woods are marketed by species, the easiest method of selecting woods for painting

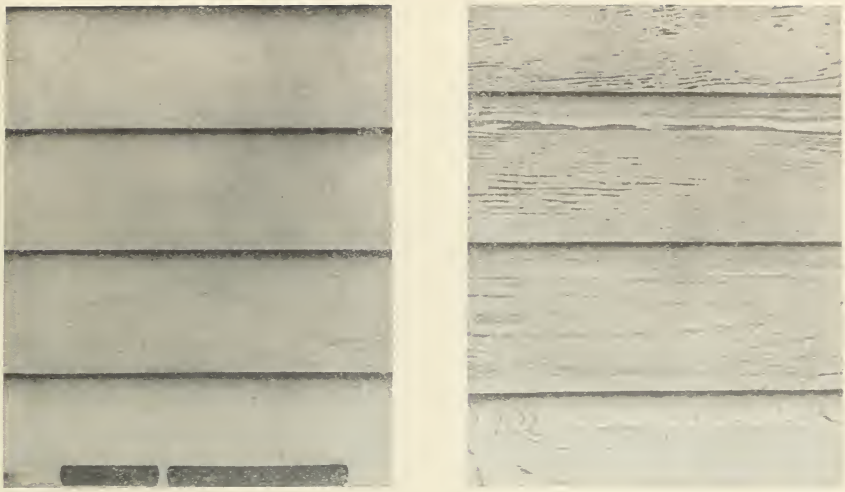

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Figure 5.—Paint wears longer on some woods than on others. A good house paint, after 8 years of exposure to the north, on western redcedar (two upper boards at left), on eastern white pine (two lower boards at left), on Douglas-fir (two upper boards at right), and on southern yellow pine (two lower boards at right).

is by species. Species alone, however, is not the most effective basis for selection because there are wide variations in painting characteristics among boards of any one species. The commercially important native woods, when purchased in lumber of the higher grades, are classified for painting characteristics into five groups:

Group I: The cedars, baldcypress, and redwood, all of which are softwoods. Woods of group I hold all of the common kinds of house and barn paints well.

Group II: Eastern white pine, sugar pine, and western white pine, all of which are softwoods. On woods of group II, paints containing zinc oxide are slightly less durable, but other paints are as durable as on woods of group I.

Group III: White fir, the hemlocks, ponderosa pine, and the spruces of the softwoods; aspen, basswood, cottonwood, magnolia, and yellow-poplar of the hardwoods. Paints deteriorate somewhat more rapidly on woods of group III than on woods of groups I and II. On ponderosa pine, paints containing zinc oxide are less durable than paints free from it.

Group IV: Douglas-fir, southern yellow pine, and western larch of the softwoods; beech, birch, the gums, and maple of the hardwoods. Paints deteriorate more rapidly on woods of group IV than on woods of groups I, II, and III. On southern yellow pine, paints containing zinc oxide are less durable than paints free from it.

Group V: Ash, chestnut, elm, hickory, oak, and walnut, all of which are hardwoods with large pores. Woods of group V require wood filler to fill the pores before smooth coatings of paint or enamel can be applied.

SELECTION BY GRADE

Most lumber is graded for sale. In softwood lumber the better grades for painting are the select grades. Select grades of lumber permit few knots, pitch streaks, or pitch pockets. Common grades in which defects are numerous cannot be expected to hold paint as well as the select grades.

SELECTION BY KIND OF GRAIN

Some woods are cut into lumber in such a way that the boards in the highest grade are always edge-grain. The term "vertical grain" is sometimes used instead of edge-grain; among hardwoods the term "quarter-sawed" has the same meaning. For good painting, edge-grain lumber should be purchased whenever possible. When flat-grain boards are used, it is desirable to turn them so that the bark side will be the surface exposed for painting. The bark side is the side toward which the annual growth rings are convex.

SELECTION BY DENSITY AND TEXTURE

In commercial shipments of many kinds of lumber there will be found a wide range in density, and in width of growth rings. Paint maintenance can often be improved by setting aside those boards that are much above the average in weight or in width of summerwood bands. The heavy, wide-ringed boards may be used for construction that will not be painted, for less important parts of the structure, or for parts that receive little sunshine. (Paint will last longer on any board if it is in a shaded rather than a sunny place.) As a rule, the time for repainting a house is determined by the wearing out of paint on the poorest boards.

SUGGESTIONS FOR PAINTING THE HEAVIER SOFTWOODS

The forests of the United States produce much more lumber of species classed in groups III and IV than of species in groups I and II. For that reason woods that tend to shorten the life of paint coatings often must be painted. In such cases the unfavorable effect of the wood can be reduced by careful selection and application of paint the first time the structure is painted.

Painting should be done as soon after erecting the woodwork as is practicable, usually within a week. It is not good practice to allow wood to weather for weeks or months before painting. The first or priming coat of paint may be applied, if convenient, before the lumber is delivered at the site of the building. If this is done, both sides of the boards should be primed to avoid the cupping or warping that might otherwise occur from unequal rate of change in moisture content on the two sides. Although priming of butt ends is often omitted, the best practice is to

paint the butt ends with primer after cutting and fitting the boards, but before fastening them in place.

If woods of groups III and IV are primed with aluminum house paint before applying house paint of the desired color, they can be made to hold their paint coatings nearly as long as woods of groups I and II (fig. 6).

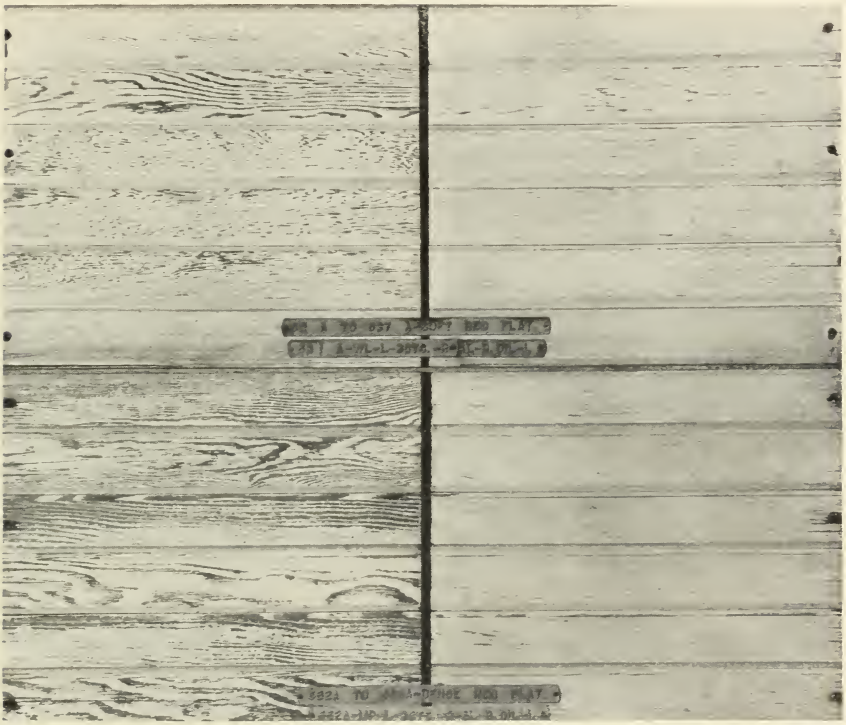

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Figure 6.—Aluminum priming paint improves the durability of house paints on woods that have wide bands of summerwood. These painted panels of Douglas-fir were exposed to the weather for 5 years, facing south. The left-hand halves were painted with three coats of white paint; the right-hand halves were painted with one coat of aluminum house paint followed by two coats of the same white paint that was used on the left-hand halves.

Aluminum house paint is made for use on exterior woodwork; aluminum paints or enamels made for other purposes are unsuitable for priming wood. The paint job consists of one coat of aluminum house paint followed by two coats of house paint of good quality. So applied, white paint or any of the light colors should last about 4 years on woods of groups III or IV before further painting is necessary. Paints of dark color may last 2 or 3 years longer. When repainting, apply only the white or colored paint.

Next best to aluminum house paint for priming woods of groups III and IV are modern house-paint primers that contain no zinc oxide and that

have the property commonly called "controlled penetration" (fig. 7). Many manufacturers of commercial house paint now make such house-paint primers. The painting may be done in either three- or two-coat work. If three coats are applied, the house-paint primer may be thinned with a small proportion of turpentine or mineral spirits and applied so that 1 gallon of the mixture covers about 600 square feet of surface. After that,

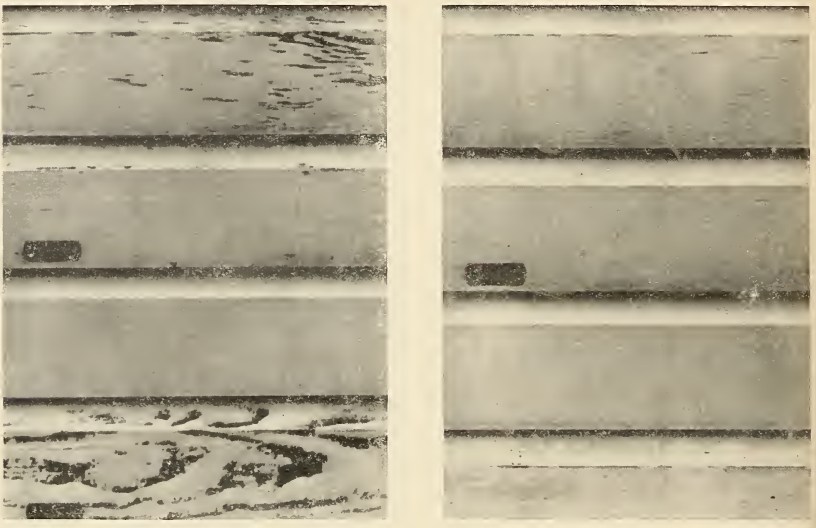

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Figure 7.—Special house-paint primer makes it possible to paint all woods satisfactorily, even those of group IV, with only two coats. Panels at the left and at the right are adjacent areas of the same boards of Douglas-fir (first and third boards from the top) and of southern yellow pine (second and fourth boards). The panel at the left was painted with two coats of white paint; the panel at the right was painted with one coat of special primer and one coat of the same white paint. Panels were exposed to the weather, facing south, for 3 years.

two coats of house paint in white or a chosen color should be applied, and each coat spread over 700 square feet to the gallon of paint.

In two-coat work the house-paint primer is not thinned and is applied in a thicker coating so that a gallon covers no more than 450 square feet of surface. A single coat of good house paint is sufficient over such a primer coat, provided it is applied so that a gallon covers no more than 550 square feet of surface.

Thus, although the best paint service is most easily obtained when wood of the most favorable kind has been selected, good paint service is possible even on the less suitable kinds of wood if the right kind of paint is applied properly the first time the wood is painted.

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